THE COLORS OF NORTHERN APETALOUS FLOWERS.

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THE dicotyledons, which include about two-thirds of flowering plants, were divided by Jussieu and Enlicher into three divisions — the Polypetalæ, the Gamopetalæ, and the Apetalæ — an arrangement familiar in most of our floras. The highest type of a flower, according to De Candolle, was one that had all the organs present, but inserted separately upon the receptacle; for it may be argued, as A. Gray remarks, that fusion is an arrest of development, and therefore an indication of low rank, or less perfection, than the contrary. Accordingly the Polypetalæ were placed at the head of the vegetable kingdom. The morphological doctrine that the flower is a metamorphosed bud or branch, and that the union of its parts marked an upward progress, was not made the guiding principle in the arrangement of plant families in a lineal series until a comparatively recent date. The miscellaneous group of dicotyledonous families, known as the Apetalæ, were believed to be retrogressive or degraded forms derived from both the Polypetalæ and Gamopetalæ, which had once possessed petals and conspicuous flowers. This division, as originally constituted, was made the receptacle for families the affinities of which were obscure; and, in the absence of knowledge as to its true position, was placed as a sort of appendix after the Gamopetalæ. It required the united labors of Braun, Hanstein, and Engler to determine and place in their proper collocation those families which are clearly reductions, and to point out that those remaining are not derived from the higher orders, but are primitive in character. They are naked blooming, according to Eichler, rather than abortive.

In many of the true apetalous families the perianth has remained rudimentary, and in those of lowest rank has never

been differentiated into calyx and corolla. It is either wanting, or is represented by a number of small scale-like bodies, indefinite in number, sometimes present in the staminate and replaced by bracts in the pistillate flowers; or it may be so ambiguous as to leave its morphological significance in doubt. Gradually in the rise of the flower from its primordial stage the perianth becomes more and more important, until in the pink family, which occupies an intermediate position, the corolla is large and conspicuous. The flowers are very generally wind-fertilized, and, as may be observed in the grasses and sedges, this is not favorable to the high development of the floral envelopes. Mechanical difficulties are also presented by the aggregation of the flowers in a dense inflorescence. For instance, in the staminate ament of the alder, where the calyx is present, I found by actual count in an ament two and a half inches long seventy-seven flowers; while in the staminate ament of the willow (*S. discolor*), of about half this length, there were two hundred and seventy flowers, or seven times as many flowers to an inch in length. There is no room for a perianth, and the office of protection has been assumed by scales and woolly hairs.

Though the larger part of the families are anemophilous or self-fertilized, their coloration is highly interesting as showing what colors the bracts and perianth would develop naturally as the result of chemical and physical influences, and in a limited number of cases the effect upon such flowers of insect visitors at a later period.

Lowest in rank of the choripetalous series stands the order of the Piperales, with perfect flowers in slender spikes destitute of a perianth, and divided, according as the carpels are separate or distinct, into the Piperaceæ and Saururaceæ. The former is a tropical family, but the latter is represented in eastern America by *Saururus cernuus*, lizard's tail, a name suggested by the slender spike with drooping apex. The flowers are fragrant, with white stamens, and probably attract insects.

A large number of shrubs and trees have the flowers in aments and are frequently referred to as the Amentaceæ. They are widely distributed throughout the temperate and

northern regions, and have been developed to endure severe climatic conditions. They are or were wind-fertilized, the monœcious or diœcious flowers appearing in early spring, when there are no leaves to intercept the pollen.

There are about thirty-five species of the Juglandaceæ, which include the walnut and hickory, large trees valuable for timber and fuel. The flowers are green; the staminate form a long drooping ament, while the pistillate are solitary, or few in a cluster. The perianth is present in both forms. In Juglans there are four narrow petals in the sinuses of the calyx; but in Hicoria they are wanting. An abortive ovary rarely occurs in the staminate flowers.

In the Myricaceæ, or bayberry family, neither the male nor female flowers possess a perianth, but its place is taken by several bracts near the flower.

The Salicaceæ form a large family confined almost entirely to the north temperate and arctic zones. It includes the poplar and the willow. The poplar has no perianth, but the receptacle is extended to form an oblique, cup-shaped disk. In early spring the pollen is expelled forcibly a short distance by the elastic purple anthers. In the genus Salix so variable are the species and so freely do they hybridize that any entirely satisfactory treatment from a systematic standpoint is impossible. The Swedish botanist Anderson, whose standard monograph, published in the Prodromus of De Candolle, was the work of nearly twenty-five years, declared that he never saw two specimens of *Salix nigricans*, which has one hundred and twenty synonyms, that were exactly alike. In Great Britain the number of species have been placed all the way from twelve to eighty. This genus is exceedingly interesting to the evolutionary botanist, since it so fully refutes the ancient dogma of the constancy of species. Though the flowers were formerly anemophilous, they are now fertilized by insects. There is an abundance of honey, a sweet perfume, and the bright yellow stamens render the blossoms very conspicuous. As an evidence of their attractiveness, it may be mentioned that they are collected in England for decorative purposes on Palm Sunday, and are offered for sale in New England cities by

street flower-venders. In *S. candida* and *S. purpurea* the anthers are red, and in the former the style is also dark red; but usually the anthers are yellow. The scales display considerable range in coloration; in *S. purpurea* and several other species they are purple; in *S. nigra*, yellowish; in *S. myrtilloides*, greenish-yellow, capsules reddish-green; in *S. uva-ursi* the scales are rose red at the tip; in *S. humilis* and *S. tristis*, dark red or brownish. The twigs also vary much in color; as green, white-woolly, yellow, brown, red, crimson, and purple. The willows are very attractive to insects and on a warm day they may be observed hovering in clouds about the bright yellow sprays of bloom. The pistillate aments are not so conspicuous as the staminate, and in the case of *S. discolor* attract a smaller number of visitors. On the flowers of this plant I have collected five bees, nine flies, and two beetles. Species of Andrena, seeking food for their young, and flies are very common.

The inflorescence of the Betulaceæ, birch family, is anemophilous, and usually monœcious There is no corolla. In Carpinus, Ostrya, and Corylus the calyx is present in the pistillate flowers but wanting in the staminate; conversely, in Betula and Alnus the staminate flowers have a calyx and the pistillate have not. Originally the calyx was doubtless present in both forms. Its presence or absence in the one sex or the other of the different genera has been largely influenced by mechanical conditions. In the fertile flowers of the hornbeam, hop-hornbeam, and the hazel there are but few blossoms in the capitate inflorescence, while the sterile flowers are more densely aggregated. An opposite condition prevails in the birch and alder, where, though both kinds of aments contain numerous flowers, they are more densely aggregated in the fertile than in the sterile. Where declinic flowers are solitary, or few in a cluster, as in Fagus, Castanea, Asparagus, and *Ribes nigrum*, both forms possess a perianth. The hazel (Corylus) derives its English name from the color of the nuts, as "in hue as hazelnuts," Shakespeare, *Taming of the Shrew*, II, 1.[1] The staminate aments are yellow, and in autumn the leaves also become

[1] *Enc. Brit.*, vol. xi, p. 548.

a handsome yellow. The thread-like stigmas of the pistillate are bright scarlet. In *C. purpurea* the leaves, husk, and pellicle of the kernel are purple. The hornbeam has the anthers pale yellow and the inner bark yields a yellow dye. In the genus Betula the flowers are greenish-yellow and the leaves are a pale yellow in spring and a bright yellow in autumn. The aments of Alnus are a reddish-brown, and the leaves turn to a dull dark brown. The styles, as a rule, in early flowering spring plants are crimson, a coloring which, by converting light rays into heat, favors the growth of the pollen tubes. In several instances I have seen the male flowers of *Alnus incana* visited by the honey-bee for pollen. Müller states that he has seen numerous honey-bees collecting pollen on the male flowers of the European species of hazel (*Corylus avellana*).

In the Fagaceæ, or beech family, there are no petals, but the calyx is present in both kinds of flowers. In the beech, one of our handsomest trees, the greenish-yellow calyx is bell-shaped, 5–8-cleft in the staminate, but 6-lobed in the pistillate flowers. The inflorescence is in small clusters. In the chestnut (*Castanea dentata*) the flowers are exceedingly abundant and give a yellowish tinge to the whole tree. The staminate flowers may contain an abortive ovary and the pistillate five to twelve abortive stamens; the former are in aments, the latter clustered several in an involucre. The flowers of the oak are greenish, sometimes reddish, as well as the scales of the involucre and the leaves in autumn. The species of Quercus are exceedingly variable. Of *Q. robur* there are twenty-eight varieties, while several other species have from eight to ten. No sharp line of demarcation is possible, as they grade into each other by many intermediate forms. At the time of his revision of the family De Candolle wrote, "It is difficult to believe that above one-third of the actual species in botanical works will remain unchanged." The wood of the Fagaceæ is commonly brown or reddish-brown, the inner bark of *Quercus velutina* (*tinctoria*) is orange and yields a yellow dye.

It has been shown that the scales and perianth of the Amentaceæ present a wide range of coloring, including nearly every hue save blue. If the flowers were once entomophilous, as

has been maintained, and are the result of extensive degeneration, then these colors may be the relics of an earlier higher stage. But if the perianth has always remained rudimentary, and the form of the inflorescence has been developed in connection with wind-fertilization, then the coloring is due largely to chemical and physical conditions. It is desirable to consider briefly the origin of the ament, for which the Fagaceæ present special advantages. The ament, though frequently referred to as a spike, is in reality a contracted panicle. It is composed of clusters of flowers with a common involucre arranged around a central axis or rachis, and is, consequently, a branch system with the lateral axes of the first and second order, which would bear solitary flowers, aborted or eliminated. In the oak the female flower still remains solitary, and with the involucre of many bracts represents a non-developed branch; further steps are presented by the beech with two flowers, and the chestnut with several in an involucre. The association of these clusters along a common rachis would produce an ament, the production of which is the result of contraction and concentration, of elimination of axes, and arrested development. There is no evidence that the perianth was ever large and well developed. The primitive flowers were probably perfect and possessed a simple and undifferentiated perianth, which in certain genera has been wholly or in part replaced by bracts or scales. The Piperales are regularly perfect, and rudimentary ovaries and stamens are of frequent occurrence in the Amentaceæ, especially in the Fagaceæ. The causes which have led to the separation of the sexes are still involved in much obscurity, though it is well known that nutrition and climate influence differently the stamens and pistils. It is evident, however, as Darwin has remarked, that cross-fertilization must have been assured before the flowers became declinic, since otherwise the species would have perished. When the antiquity of these families, their wide geographical distribution, the vast number of individuals,— in the case of the birch forming vast forests in Russia, — as well as their floral structure, are considered, there seems no reason to suppose that the flowers were ever entomophilous and conspicuous.

The order of Urticales does not show any advance in the structure of its flowers over the Fagales. The order is a large one, comprising some fifteen hundred species, distributed chiefly through tropical regions. The flowers are small, in inconspicuous spicate or axillary clusters, greenish, and anemophilous. In Ulmus (elm), of the Ulmaceæ, the flowers are a reddish-purple, and the wood of *U. fulva* is reddish also. The Moraceæ, mulberry family, is composed of trees and shrubs with milky juice. The flowers are greenish, but in fruiting the calyx or receptacle becomes fleshy and bright-colored; in Morus, red-purple and white; in Toxylon, yellowish-green; and in Broussonetia the drupes are red. Of the tropical genus Ficus there are six hundred species, three of which occur in the Southern States. Its manner of fertilization has been the subject of much discussion. The hollow, pear-shaped receptacle is lined with male and female flowers, and pollination is effected by small wasps, which force their way into the cavity for the purpose of depositing their eggs. In fruit the enlarged receptacle becomes deep purple, purplish-red, orange, yellow, and whitish, and is eagerly devoured by birds, especially parrots. The greenish fruiting bracts and achenes of *Humplus lupulus* (hop) bear numerous yellow glands from $\frac{1}{260}$ to $\frac{1}{140}$ inch in diameter. When fresh they are filled with a yellow liquid containing wax and resins and a bitter-tonic medicinal principle called *lupulin*. About one ounce may be obtained from one pound of hops. These glands doubtless protect the flowers from attacks of aphides. Glandular-leaved peach and nectarine trees are less subject to curl, to mildew, and to the attacks of aphides than the non-glandular (Darwin, *Animals and Plants under Domestication*, Vol. I, p. 364). The hop in some years is attacked by vast numbers of *Aphis humuli*, and is also subject to blight from a parasitic fungus. The flowers of the nettle family are green, wind-fertilized, and the pollen is scattered by the explosion of the anthers.

The order Santalales includes about seven hundred and fifty species, which are most abundant in tropical regions, only six species being found in the Northern States. The two northern species of the Loranthaceæ, mistletoe family, are parasitic

plants which contain chlorophyll, and are yellowish or brownish green. Tropical species of Loranthus produce magnificent flowers 10–20 cm. in diameter and display most gorgeous orange and purple colors. The flowers of the Santalaceæ, sandalwood family, are perfect, the calyx is greenish-white or purplish, and at least one species in Europe has been seen to be visited by the honey-bee.

The colors of the Balanophoraceæ, a tropical family parasitic on the roots of forest trees, which belongs also to this order, are of much interest. The plants, of which there are about forty species, resemble fungi, such as toadstools, producing flowers. They were, according to Kerner, made the subject of many fanciful speculations by the nature-philosophers, by whom they were considered as "in the position of a hieroglyphic key between two worlds." The entire plant of the American genus Langsdorffia is pale yellowish or, in the case of the scales, waxen yellow, orange, or red. The genus Balanophora occurs in the eastern hemisphere and is vividly colored a deep yellow, red, or purple. In Helosis the floral spadix is purple or blood-red; in *Corynæa turdici*, which lives on the roots of Peruvian-bark trees, the purple spadix is supported by a white shaft. The coloring of the inflorescence of *Lophophytum leandri* "cannot be exceeded," says Kerner, "in variety, its rachis being pale reddish-violet, the bract scales gamboge, the ovary yellowish, the styles red, and the ovaries white." The entire plant of *Sarcophyte sanguinea* from the Cape of Good Hope presents a most striking appearance, owing to the blood-red coloring of all its parts.

The flowers of the Aristolochiaceæ, or birthroot family, are adapted to Diptera, especially to small gnats. The calyx is highly specialized and in Aristolochia, familiar in *A. sipho*, Dutchman's pipe of cultivation, is prolonged into a tube with a contracted throat, either straight or shaped like the letter *S*, which is set on the inside with reflexed hairs. Flies can creep inside easily, but when they attempt to escape they are prevented by the hairs, which form an impassable grating. As soon as the anthers have dehisced, the hairs wither, the calyx shrivels, and the imprisoned insects are set free. The mechanism

of Aristolochia, which was first studied by Sprengel, "was long," says Müller, "the only example known of a temporary prison for insects." Progressive steps toward this structure are presented by Asarum and Heterotropa. The flowers of Aristolochia are lurid purple, with a yellowish-green tube; the tube of Asarum is greenish or brown-purple, puberulent with purple hairs; or in *A. macranthum* the tube is mottled with violet within. According to Kerner, South American species of Aristolochia are of immense size and are used as caps by children at play; in color they are a combination of cream and deep maroon purple. Purplish coloring of bracts and sepals is of so common occurrence, even extending to the whole plant, that in this family it has doubtless been developed directly from the primitive green without passing through any intermediate stage. The flowers should be compared with the pitcher-like leaves of Sarracenia and the spathes of Arum, as all three serve as traps for small flies and are lurid purple, a color probably attractive to these insects. Rudimentary petals occur in *Asarum canadense*.

The flowers of the Polygonaceæ, or buckwheat family, are devoid of petals and are wind-fertilized, as in Rumex, or autogamous or entomophilous, as in Polygonum. In the genus Eriogonum, growing west of the Mississippi, the campanulate calyx is usually yellowish or white, sometimes changing to pink. The calyx of Rumex (sorrel) is small and commonly green, but in *R. venosus* it is red, and the fertile panicles of *R. acetosella* turn reddish; but the achenes, or fruit, are usually red, and frequently the stems and leaves, as in *R. sanguinea*. Red butterflies, which are attracted by red coloration, were often seen by Müller in the Alps seated upon the plants when in seed, and a species of Halictus was observed frequently collecting pollen. The plants of the Polygonaceæ tend to develop red rather than yellow coloration; but in *Rumex persicarioides* (golden dock) the fruiting calyx becomes orange-colored, and the roots of several species of dock are yellow.

Of the thirty-eight species of the genus Polygonum (knotweed) ten are white, ten red, three purple, and fifteen green.

Conspicuousness is gained by the union of the flowers in axillary or terminal clusters. The green flowers are very small, odorless and honeyless, and self-fertilized. The white and red are more conspicuous, may contain honey, and are visited by few or numerous insects; for instance, *P. persicaria* has a white or red calyx, secretes honey sparingly, and is visited by many flies and small bees. The species of this genus most excellently illustrate the successive steps by which a green perianth may become conspicuous. In the common door-weed (*P. aviculare*) the margins of the sepals are white, turning pink, while the centers remain green. The flowers are self-fertilized, but are occasionally visited by flies. In *P. convolvulus* the two inner divisions of the perianth are entirely white, but the outer are keeled with green; the calyx of *P. virginianum* is usually green, tinged or tipped with white; *P. persicaria* has in the same spike green, white, and red flowers; while *P. orientale*, cultivated from India, has large, bright rose-colored flowers. In the case of the familiar buckwheat (*Fagopyrum fagopyrum*) the waving fields of white bloom are very conspicuous. The dimorphic flowers possess perfume, and insects manifest special preference for the honey; in Germany Müller has enumerated forty-one visitors, of which twelve are bees. Cross-fertilization is insured and self-fertilization rendered difficult. The marked tendency of both the vegetative and floral organs in this family to develop reddish coloration is evidently due to bright sunlight and the chemical constitution of the sap, for the Alpine bistort (*P. viviparum*) of the White Mountains often has little red bulblets in place of the flesh-colored flowers. In *P. scandans* and *P. dumetorum* the calyx is yellowish-green.

The Chenopodiaceæ is a large family consisting chiefly of herbs of a homely aspect. To it belong the garden beet and the pot-herb spinach. The green flowers are very small, usually clustered, and in many species unisexual. The calyx is usually present, but is wanting in the pistillate forms of some genera. As in the Polygonaceæ, certain species show a tendency to develop red coloration; *Chenopodium rubrum* has a red calyx, and the inflorescence of *C. album* often turns reddish

in autumn, as well as the stem. In *Blitum capitatum* (strawberry blite) the reddish calyx becomes bright red and juicy in fruit, the globular, axillary heads resembling a strawberry; in *Salicornia herbacea* the whole plant turns bright red in autumn, "forming vividly covered areas in the salt marshes, hence called *Marsh samphire*." The large converging lobes of *Salsola kali* become rose-colored, and the leaves and outer branches of *S. tragus* also turn bright red at maturity. Many of the species are halophytes, most abundant by the sea and in the salt marshes of Central Asia and in the basin of the Great Salt Lake of Utah. The pollen is dust-like and the flowers are anemophilous, or autogamous, though rarely visited by pollen-eating flies. *Dondia americana* has purple-green sepals.

The red coloration noticed in the two preceding families is also highly developed in the Amaranthaceæ. This is not so much observable in our native species as in cultivated forms. The foliage of the ornamental Amaranthus is richly variegated with deep red, yellow, and green, and the flowers are dark red. In *Amaranthus hypochondriacus* from Mexico the entire plant is tinged with red; while the whole plant of *A. melancholicus* from eastern Asia is purplish. The crests of the flowers of *Celosia cristata* (cockscomb) from India are rose, crimson, yellow, and white; in *Gomphrena globosa* (globe amaranth) the dense round heads are crimson, orange, purple, and white. In this family the sepals are separate, or united at base, or in Frœlichia form a tube.

In the Nyctaginaceæ (four-o'clock family) the calyx is campanulate or salver-form, corolla-like, with a deciduous limb. The involucre resembles a calyx. The flowers are entomophilous and mostly pink or red in northern species; but in *Abronia fragrans* the slender flowers are white, fragrant, opening at night and adapted to nocturnal Lepidoptera. Florists offer yellow, white, and red varieties of *Mirabilis jalapa*. The sweet-scented *M. longiflora* is white, with a tube 15 cm. in length and adapted to night-flying Lepidoptera. The limb stands edgewise and is designed to render the flower more conspicuous in the evening and not as a landing place for insects.

The Portulaceæ and Caryophyllaceæ usually possess a corolla, though it is sometimes wanting. The colors of the flowers of the Portulaceæ are white, yellow, and red. *Portulacea oleracea*, which, Warner fitly remarks in his charming essays on gardening, "grows with all the confidence of youth and skill of old age," has yellow flowers and red stems; *P. pilosa* has red flowers, and the intermediate stages between red and yellow are shown by the cultivated *P. grandiflora*. In this latter species the white flowers have green stems, and the yellow and red flowers red stems.

In the Caryophyllaceæ, a large family of some fifteen hundred species, there are in the Northern States fifty-six white, twenty-two red, two purple, and eight green flowers. The green flowers are apetalous. Both the green and smaller white-flowered species are low, tufted, weak herbs of a spreading or ascending habit, represented by the chickweeds and sandworts. The flowers are solitary or, at least, not densely clustered, and usually white, or in Spergularia reddish. The honey is freely exposed and the pollinators are chiefly flies, beetles, and the smaller bees, such as Andrena and Halictus. Certain species are visited also by butterflies and moths and by the cosmopolitan honey-bee. I have never observed and have been unable to find any record in the works of Müller and Knuth of the visits of bumblebees. Many of the species are dichogamous, but self-fertilization is always possible. The chickweed (*Alsine* (*Stellaria*) *media*), so widely distributed as a garden weed, may be taken as a representative species. The individual flowers are quite inconspicuous, but they are numerous and, in contrast with the green foliage leaves, can be seen at a considerable distance. I found on trial that a flower could be distinctly seen at a distance of twenty-five feet; but after removing the petals it was visible only about four feet. The plants blossom throughout the entire year, except when prevented by severe weather, and in early spring and late fall, when there are few other flowers in bloom, are very frequently visited by flies. In April, Müller collected in Germany six of the less specialized bees and four Diptera, and in the middle of October I collected in Maine five species of Diptera

and Andrena. The honey is abundant. In winter the flowers fertilize themselves. The white petals in these genera may in part be due to the non-formation of chlorophyll, and in part to the selective influence of the visitors in choosing the more conspicuous flowers. Insects have also probably aided in the preservation of the petals, for in certain species of Alsine and Sagina they are sometimes present and in other instances are wanting.

The pinks proper, or Sileneæ, exhibit a wonderful variety of red shades, varying from white, through rose, pink, and deep red, to scarlet and crimson. The petals may be dotted or marbled with white, with a white center, surrounded with a purple ring, as in *Dianthus deltoides*. The corolla is often notched or fringed and surmounted by a corona of scales. The perfume is aromatic, and the honey is deeply concealed. The red flowers are very attractive to butterflies, which are the chief visitors, while the white species are adapted to night-flying Lepidoptera. The following table, prepared from Müller's *Alpenblumen* and Knuth's *Handbuch der Blütenbiologie*, shows the importance of butterflies as fertilizers of red flowers.

VISITORS TO RED-FLOWERED SPECIES.

	Length of Tube in Millimeters.	Butterflies.	Millers.	Hymenoptera.	Diptera.	Coleoptera.	Total.
Silene acaulis	10	19	4	3	4	1	31
Lychnis flos Jovis	10	3			1		4
L. ruba	10–13	11	1		1		13
Saponaria ocymoides	10–12	28	5	3	2		38
Dianthus sylvestris	18–25	1					1
D. atrorubens	13–15	4	1				5
D. deltoides	12–14	9	2				11
D. carthusianorum	12	9	6				15

The carmine flowers of *Silene acaulis*, which grows in the higher Alps, are so frequently visited by butterflies that the power of self-fertilization has been nearly lost. Both the species of Lychnis have bright red, beautiful flowers and

attract many butterflies. The handsome red flowers of *Saponaria ocymoides* are very abundant on sunny slopes in subalpine regions and are sought by twenty-eight species of butterflies. The species of Dianthus have the calyx tube so long and narrow that the honey can be reached only by Lepidoptera. The flowers are rose or dark red, elegantly marked, of large size and great beauty. The association of bright red coloration with a slender calycine tube and fertilization by butterflies is not a coincidence, for throughout the Caryophyllaceæ in proportion as the flowers increase in conspicuousness the power of self-fertilization is lost.

"As the honey gets more deeply concealed and access more directly limited to butterflies, we find," says Müller, "*pari passu* among the Caryophyllaceæ increasing development of sweet scents, bright red colors, fine markings round the entrance of the flower, and indentations at the circumference. All these characters which are so attractive to us seem to have been produced by the similar tastes of butterflies." This view is much strengthened when it is considered that the nocturnal flowers of the genera are white, and without variegation. *Saponaria officinalis* is pale pink, or, on expanding, white, with the perfume strongest in the evening; *Silene nutans*, *S. noctiflora*, and *Lychnis alba* all have white or pale pink flowers and are visited by night-flying Lepidoptera. Since red is invisible at night, while white is conspicuous, it is evident that the former color would be disadvantageous to nocturnal flowers. Originally the flowers of these genera were probably pale pink or whitish, as in Gypsophila, where they are small, reddish, the tube short, the honey fully exposed, and the visitors a miscellaneous company of flies, bees, and Lepidoptera. A part of the species became adapted to butterflies and a part to moths; no new colors were developed, but the red and white were differentiated. The sexual markings of butterflies show that they are in a very high degree color-loving insects, and while they visit flowers of all colors they certainly prefer bright hues to dull, and as with rare exceptions butterfly flowers are red, it is probable that they find this color most attractive.

Under cultivation the pinks have proved susceptible of great

improvement, and numberless splendid varieties have been produced of every shade of red, dotted and striped, or marbled and angled with white. In *Dianthus barbatus* (the sweet-william) white and two different shades of red florets may occur in the same fascicle, the white turning pink with age. Florists also offer pure white and yellow forms, and white and yellow varieties bordered with red or purple. Yellow, which is well shown in Dianthus, is a comparatively rare color in the Caryophyllaceæ.

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ORDERS.	FAMILIES.	GREEN OR DULL COLOR.	WHITE.	YELLOW.	RED.	PURPLE.	BLUE.	TOTAL.
Piperales	Saururaceæ		1					1
Juglandales	Juglandaceæ	13						13
Myricales	Myricaceæ	4						4
	Leitneriaceæ	1						1
Salicales	Salicaceæ	9		32	2			43
Fagales	Betulaceæ	7		11				18
	Fagaceæ	25						25
Urticales	Ulmaceæ	3				4		7
	Moraceæ	6						6
	Urticaceæ	8						8
Santalales	Loranthaceæ	2						2
	Santalaceæ	2	2			1		5
Aristolochiales	Aristolochiaceæ					10		10
Polygonales	Polygonaceæ	33	22	5	11	3		74
Chenopodiales	Chenopodiaceæ	38			1			39
	Amaranthaceæ	16	1					17
	Phytolaccaceæ		1					1
	Nyctaginaceæ		1		4	3		8
	Aizoaceæ		1			1		2
	Portulacaceæ		4	3	5			12
	Caryophyllaceæ	8	56		22	2		88
	Total	175	89	51	45	24		384

SUMMARY.

1. The apetalous Choripetalæ (Saururaceæ-Aizoaceæ) are of primitive character; and are, or were, autogamous or anemophilous. In the formation of the dense inflorescence

characteristic of many genera there has been much contraction attended by the elimination of axes, leaves, bracts, and even of the perianth, but the flowers are not degraded entomophilous forms. Consequently, when the flowers possess bright colors they are not the relics of a higher stage of coloration developed by the selective tastes of insects, but are due to the chemical constitution of the nutritive fluids and the action of light and heat.

2. The absence of blue is noteworthy. Yellow is not common, but is well shown in the scales and calyx of Betula. The inner side of the calyx of *Mollugo verticillata* is whitish, and in Polygonum the margins or entire calyx is white. Red is very common and occurs in many genera. Purplish flowers also occur, as *Sesuvium maritimum*. There is evidence derived from this group of families that if anthophilous insects were devoid of color sense, they still would have developed white, yellow, red, and purple flowers, though they would be less frequent and of duller shades.

3. A number of genera have become entomophilous, and this change in the manner of fertilization has been attended by an increased conspicuousness of the flowers. The anthers of Salix, formerly a wind-fertilized genus, have become a brighter yellow; in Aristolochia and Asarum the calyx is a lurid purple attractive to small Diptera; and in Polygonum and several other genera clear white or deep red. Insects have not in these instances produced new colors, but have intensified those already partially developed.

4. Petals are usually present in the Portulaceæ and Caryophyllaceæ, and are white, yellow, red, or purple. The smaller white flowers of the Caryophyllaceæ are visited by flies, beetles, and the short-tongued bees, which may have aided in the preservation of the petals and in rendering them a clearer white. The larger red and white flowers are correlated with the visits of Lepidoptera; the red species with butterflies, the white nocturnal forms with moths.

WALDOBORO, ME.